

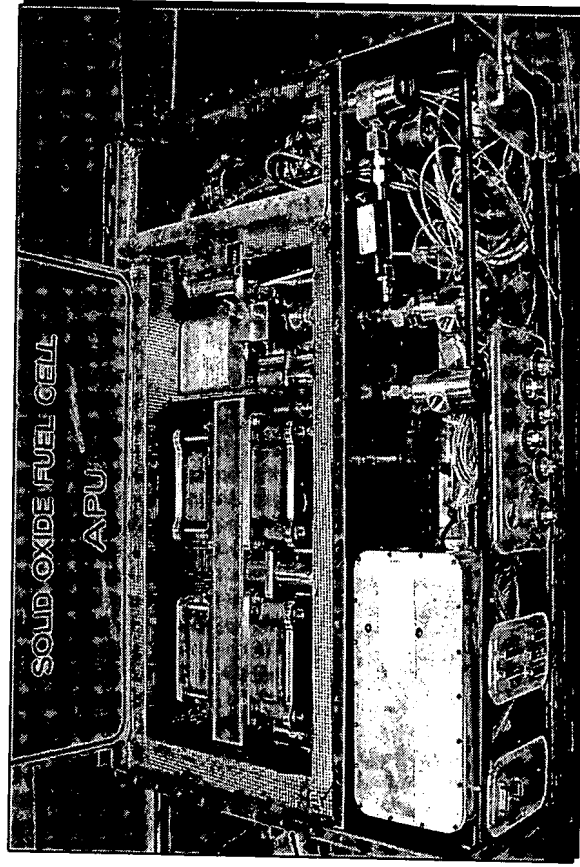
# ***Battelle Automotive Technology***

## ***Solid Oxide Fuel Cell Joint Venture***



### **SOFC Technical Progress Review**

**September 23, 2001**



**Battelle**

**Battelle Proprietary per BMI/Delphi P.I.A. of July, 2000**

**Automotive  
Technology**

SOFC 3/30/2007 1

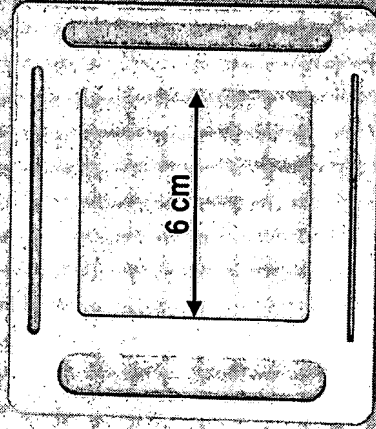
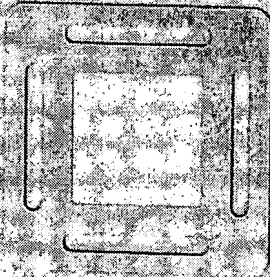
**Exhibit  
B1**



# Scale Up of SOFCs at Battelle

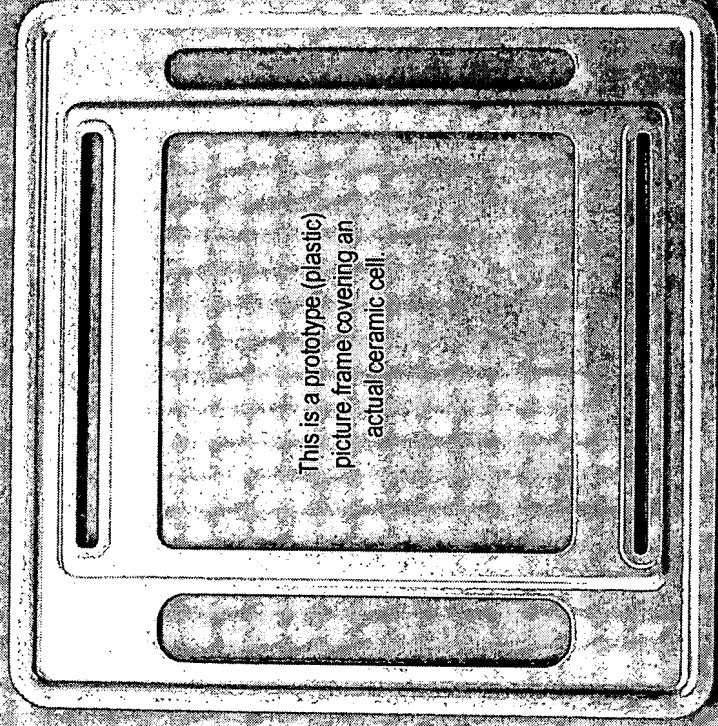
Electrode development is performed on 2.5 cm diam. cells mounted on tube ends.

Small scale stack has ~12cm<sup>2</sup> active area. Most of the 19 tests were on cell-to-edge design (not shown).



Intermediate scale stack has ~35cm<sup>2</sup> active area. First test to begin 9/19/01. All tests will be on picture frame design.

Full scale stack will be picture frame design with ~117cm<sup>2</sup> active area. Cells are now being produced. First stamped metal parts will be available in late October.

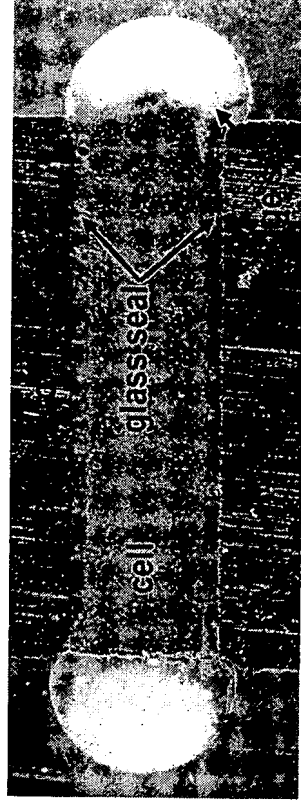


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# Glass Seals Proving Viable

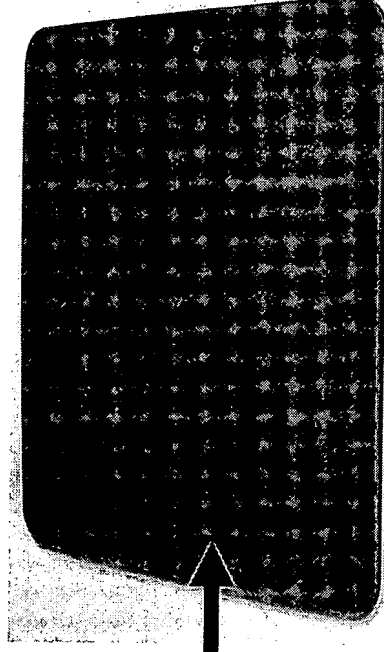
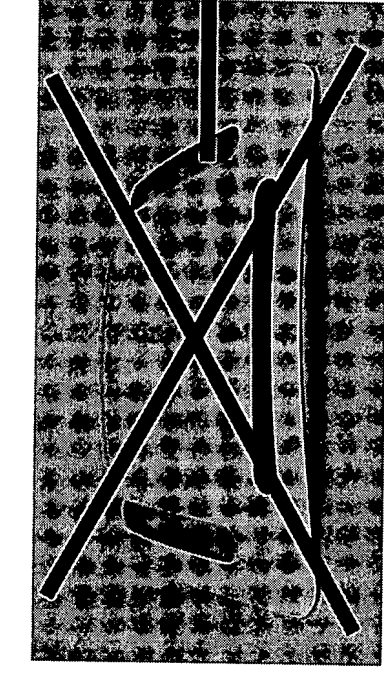
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- Glass seals were hermetic in the last four stack tests.
- Open circuit voltages were at theoretical levels.
- Glass seals performed well in thermally cycled metal/glass/metal joints (two cycles) and in thermally cycled ceria/glass/ceria joints for a non-SOFC application (about one hundred cycles).
- When metal/glass/metal joints fail, it occurs at the metal/scale interface.
- Thermal cycling of intermediate scale stacks with glass sealed cells and metal frames will begin in October.



# **Stable, Full-Scale Cells are in Production**

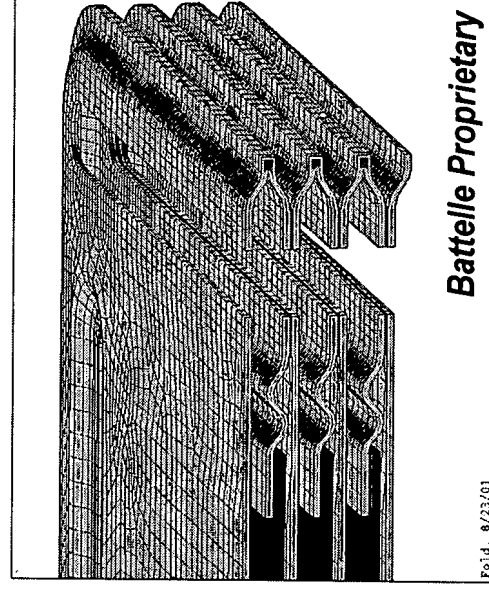
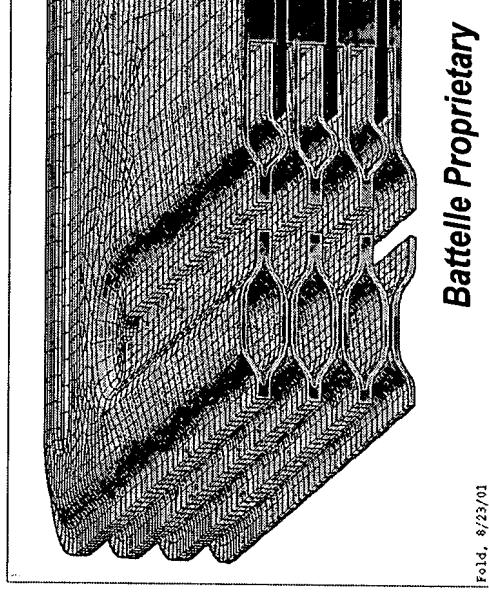
- Anode stability problem has been solved.
- The new anode is stable after reduction, and stronger as well, making return to the thinner, 600 micron anode possible.
- New innovation under development to produce nearly flat, full-size cells (12cm x 12cm) without need of extra creep-flattening step.



*Flat, stable, 600 micron, full-scale cell.*

# **Rapid Start Up: Modeling predicts $\leq 20$ minute start**

- Modeling of stacks incorporating recent design innovations indicates heating within less than 10 - 20 minutes should be possible in a well-designed and constructed stack.
- Design innovations to allow rapid start-up: (\* invention reports filed)
  - ✓ Tailor contactor to attain flat, rather than parabolic temperature profiles.\*
  - ✓ Tailor compliance of contactor to restrict out-of-plane deformation of cell.\*
  - ✓ Tailor compliance of picture frame to minimize constraint of cell edge.\*



- Adherence of oxide scale to metal not captured in modeling.

**Battelle Proprietary**

# Projections of Progress in the Near Term (Through December, 2001)

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1. Based on our analysis of power density, we expect to approach  $0.5 \text{ W/cm}^2$  at 70% utilization of POx reformate in large scale working stacks.
2. The CFD-based electrochemical model is now functional. By December we should be able to complete extensive analyses on our stack designs of steady state performance.
3. Modeling of stacks incorporating recent design innovations indicates heating within *less than 20 minutes* should be possible in BMI's proprietary design.
4. Current seals cycled at over 40 excursions *without failure*
5. Initial testing of repeated thermal cyclability of intermediate-size (7cm x 7cm) stacks scheduled for early November.
6. Test of full size (10.5cm x 14 cm) stack to be initiated in December
  - Sustained run to 1000 hrs
  - Thermal cycles
  - < 20 minute start up